AMENDMENTS TO THE SPECIFICATION:

Please amend the paragraphs beginning at page 1, line 19, through page 2, line 25, as follows:

Electrically tunable resonators are attractive components for agile radar and mobile radio communication systems. Different types of resonators are known. Dielectric and ~~parallell~~ parallel plate resonator and filters for microwave frequencies using dielectric disks of any shape, for example circular, are known e.g. from Vendik et al., Electronics Letters vol. 31, p. 654, 1995, which herewith is incorporated herein by reference.

~~Parallell~~ Parallel plate resonators comprising substrates of non-linear dielectric materials with extremely high dielectric constants, for example ferroelectric materials or anti-ferroelectric materials, have small dimensions, and they can for example be used to provide very compact filters in the frequency bands in which advanced microwave communication systems operate. Such non-linear dielectric materials may e.g. be STO($SrTiO_3$) with a dielectric constant of about 2000 at the temperature of liquid nitrogen and a dielectric constant of about 300 at room temperature.

Dielectric, ~~parallell~~ parallel plate resonators can be excited by simple probes or loops. For the majority of practical implementations the thickness of a parallell plate resonator is much smaller than the wavelength of the microwave signal in the resonator in order for the resonator to support only the lowest order TM modes and in order to keep the DC-voltages, which are required for the electrical tuning of the resonator comprising a dielectric substrate with electrodes arranged on both sides of it, as low as possible. For such resonators electrical tuning is obtained by means of the application of an external DC-biasing voltage, which is supplied by means of ohmic contacts to the electrodes acting as plates of the resonator. Tunable resonators based on thin film substrates as well as resonators based on dielectric bulk substrates are known. A resonator is considered to be electrically thin if the thickness is smaller than half the wavelength of the microwave

signal in the resonator such that no standing waves will be present along the axis of the disk. Electrically tunable resonators based on circular ferroelectric disks have recently been found attractive and have drawn much attention for example for applications as tunable filters in microwave communication systems, as well as in mobile radio communication systems.

Please amend the paragraph beginning at page 2, line 26, as follows:

Such devices are for example described in "Tunable Microwave Devices", which is a Swedish patent application with application number 9502137-4 and US Patent 6,463,308; and, "Arrangement and method relating to tunable devices" which is a Swedish patent application with application number 9502138-2 and US Patent 6,187,717 which herewith are incorporated herein by reference.

Please amend the paragraph beginning at page 3, line 1, as follows:

Substrates comprising ferroelectric materials in resonators and filters are of interest for different reasons. Among other things ferroelectric materials are able to handle high peak power, they have a low switching time, and the dielectric constant of the substrate varies with an applied biasing voltage, which makes the impedance of the device vary with an applied biasing electric field. For example US-A-5 908 811, "High Tc Superconducting Ferroelectric Tunable Filters", shows an example of such a filter which should get low losses by means of using a single crystal ferroelectric material. A ferroelectric thin film substrate is used. However, this device as well as other resonators and filters based on ferroelectric materials suffer from the drawback of the quality factor (Q-value) of the ferroelectric substrate or element decreasing drastically with the applied voltage, when a biasing voltage is applied. This has recently been established by A. Tagantsev in "DC-Electric-Field-induced microwave loss in ferroelectrics and intrinsic

limitation for the quality factor of a tunable component", Applied Physics Letters, Vol. 76, No. 9, February 28, 2000, p. 1182-84, to be a consequence of a fundamental loss mechanism (called quasi-Debye Effect) induced in the ferroelectric material by the applied biasing field. However, so far, no satisfactory solution to the problem associated with induced losses in tunable ferroelectric resonators has been found.

Please amend the paragraph beginning at page 4, line 16, as follows:

A tunable filter arrangement is also needed which comprises one ~~a~~ or more resonator apparatuses and which meets one or more of the objects referred to above. Still further a method of tuning a resonator arrangement is needed through which the above mentioned objects can be achieved, and particularly a method of compensating for the losses induced in a ferroelectric resonator substrate through electrical or electronical tuning.

Please amend the paragraph beginning at page 4, line 25, as follows:

Therefore a tunable resonating arrangement is provided which comprises a resonator apparatus, input/output coupling means for coupling electromagnetic energy into/out of the resonator apparatus, and a tuning device for application of a biasing voltage/electric field to the resonator apparatus. The resonator apparatus comprises a first resonator and a second resonator. The first resonator is a non-tunable high quality resonator (i.e. having a high Q-factor) , and the second resonator is a tunable resonator comprising a ferroelectric substrate. The first and second resonators are separated by a ground plane which, however, is common for, i.e. shared by, said first and second resonators, and coupling means are provided for providing coupling between said first and second resonators. For tuning of the resonator arrangement, a tuning voltage/electric field is applied to the second resonator. Advantageously the first resonator is a disk resonator, or a ~~parallell~~ parallel plate resonator, and the second resonator is another disk resonator or a ~~parallell~~ parallel plate resonator. Advantageously the first resonator

comprises a dielectric substrate, the electric permittivity of which does not, or substantially not, vary with applied voltage, which dielectric substrate is disposed between a first and a second electrode plate, of which electrodes the second electrode forms the ground plane.

Please amend the paragraph beginning at page 6, line 21, through page 7, line 4, as follows:

Through the application of a tuning (biasing) voltage to ~~said~~ the second resonator, electromagnetic energy will be distributed to the first resonator and, particularly, as the biasing voltage increases, more and more electromagnetic energy will be distributed or transferred to the first resonator since the resonators are coupled ~~the way they are~~. This means that the distribution of electromagnetic energy between the first and second resonators depends on the biasing (tuning) voltage or the electric field and of course the coupling means. The resonating frequency in the second resonator increases with the application of an increasing biasing voltage. As the biasing voltage increases, also the loss tangent of the second, ferroelectric, resonator will increase, at the same time as less of the electromagnetic energy will be located in it. Thereby will automatically be compensated for the increased loss tangent of the second resonator in that the influence thereof on the coupled resonator apparatus comprising the first and the second resonators will be reduced.

Please amend the paragraph beginning at page 7, line 19, as follows:

According to the invention thus a tunable resonator apparatus is provided which comprises a first resonator and a second resonator, wherein in said first resonator is non tunable, said second resonator is tunable and ferroelectric, i.e. comprises a ferroelectric substrate, whereby said first and second resonators are separated by a ground plane which is common for said first and second resonators. Coupling means are provided for

providing coupling between said first and second resonators, and for tuning of the resonator apparatus, a tuning voltage is applied to the second resonator. Particularly the first and the second resonator comprises disk resonators or ~~parallell~~ parallel plate resonators, and the common ground plane is formed by a second electrode plate of the first resonator which is common with a second electrode plate of the second resonator. The coupling means particularly comprises a slot or an aperture or similar in the common ground plane, through which electromagnetic energy can be transferred from one of the resonators to the other.

Please amend the paragraph beginning at page 9, line 11, as follows:

Figs. 1A-1F for illustrative purposes show the current lines (field distributions) for a number of different TM modes of a circular, ~~parallell~~-plate resonator,

Please amend the paragraphs beginning at page 11, line 5, through page 12, line 6, as follows:

Figs. 1A-1F disclose, for illustrative purposes, the lower order TM_{nmp} field distributions for a circular ~~parallell~~ parallel plate resonator, i.e. the TM_{010}, TM_{110}, TM_{210}, TM_{020}, TM_{310}, TM_{410}-modes, respectively. Solid lines indicate the current, dashed lines indicate the magnetic field and dots and crosses indicate the electric field. It is supposed that p=0, i.e. that the thickness of the substrate is smaller than half a wavelength in the resonator, and that the resonator only supports TM_{nm0}-modes. The field/current distributions are fixed in space by coupling arrangements (such as coupling loops, coupling probes, or a further resonator).

~~Parallell~~ Parallel plate resonators, for example in the form of circular dielectric disks and circular patches on dielectric substrates, have found several different microwave applications. The resonators are seen as electrically thin if the thickness (d) is smaller than half the wavelength of the microwave (λ_g) in the resonator, $d<\lambda_g/2$, so that no standing waves will be present along the axis of the disk. Electrically tunable

resonators based on circular ferroelectric disks have been largely investigated for applications in tunable filters. A simplified electrodynamic analysis of a ~~parallell~~-parallel plate resonator proposes a simple formula for the resonant frequency:

$$f_{nm0} = \frac{c_o k_{nm}}{2\pi r\sqrt{\varepsilon}}$$

where $c_0 = 3.10^8$m/s is the velocity of light in vacuum, ε is the relative dielectric constant of the disk/substrate, r is the radius of the conducting plate, and k_{nm} are the roots of Bessel functions with mode indexes n and m. For an electrically thin parallel-plate resonator the third index is 0. The above formula may be corrected taking fringing fields into account.

Please amend the paragraph beginning at page 12, line 21, as follows:

Fig. 2 schematically illustrates an electronically tunable resonator 10_0 based on a non-linear dielectric substrate 3_0 with an extremely high dielectric constant, e.g. STO ($SrTiO_3$) which has a dielectric constant of more than 2000 at the temperature of liquid nitrogen (N) and a dielectric constant of about 300 at room temperature. On both sides of the substrate high temperature superconductors 1_{01}, 1_{02}, e.g. of YBCO, are provided which in turn, in this embodiment, are covered by thin non-superconducting, high conductivity films 2_{01}, 2_{02} of e.g. Au. As an example the resonant frequencies of a circular ~~parallell~~-parallel plate disk resonator having a diameter of 10 mm and a thickness of 0.5 mm will be in the range of 0.2-2.0 GHz depending on the temperature and on the applied DC biasing. Such resonators can be excited by simple probes or loops as in/out coupling means. In most practical cases the thickness of a ~~parallell~~-parallel plate resonator is much smaller than the wavelength of the microwave signal in order for the resonator to support only the lowest order TM-modes, and in order to keep the DC-voltages, which are required for the electrical tuning of the resonator with a non-linear dielectric substrate as low as possible. This is discussed in Gevorgian et al., "Low order

modes of YBCO/STO/YBCO circular disk resonators", IEEE Trans. Microwave Theory and Techniques vol. 44, No. 10, Oct. 1996 which herewith is incorporated herein by reference. The field distribution of such a resonator was shown in Fig. 1A above, for the TM_{010} mode, and in Fig. 1D for the TM_{020} mode.

Please amend the paragraph beginning at page 13, line 15, as follows:

Fig. 3 schematically illustrates a diagram indicating the measured microwave performance of two resonators. In the figure the unloaded quality factor, Q, as a function of the biasing voltage (Vbias), is illustrated for a resonator in which normally conducting, i.e. non-superconducting, electrode plates are used, corresponding to Q_{II}, and for a resonator in which HTS electrodes of YBCO are used, corresponding to lines Q_I. Correspondingly the resonant frequencies are illustrated as a function of the applied biasing voltage (VB), corresponding to F_I, F_{II} for Cu electrodes and for YBCO electrodes respectively. It can be seen that at high biasing voltages (VB), it does not make much difference whether YBCO electrodes are used or if normally conducting (non-superconducting) electrode are used.

Please amend the paragraphs beginning at page 15, line 1 through line 34, as follows:

Thus the common electrode 13 forms a common ground plane for the first and second resonators 1,2. The first and second resonators 1,2 are coupled to each other through coupling means 5, here comprising a slot or an aperture in the common ground plane 13 allowing for distributing of electromagnetic energy between the two resonators upon application of a biasing voltage (V_B). For application of ~~said~~ the biasing voltage, biasing means 3 are provided comprising a variable voltage source which is connected to the ground plane 13 and to the first electrode 21 of the second resonator 2, such that for tuning of the resonator apparatus, the biasing voltage is applied to the second resonator 2. When the biasing voltage V_B is applied and increased, the resonant frequency of the

second resonator 2 will increase. Electromagnetic energy will then be relocated to the first resonator 1, which means that the increased loss tangent of the second resonator, which, as discussed above, increases as the biasing voltage is increased, will have a low influence on the resonator apparatus as such. Thus, as the biasing voltage increases, more and more electromagnetic energy will be transferred or redistributed to the first resonator 1. In this manner the increased loss in the tunable second resonator 2 will be compensated for.

Preferably the coupling slot is circular; which shape it should have depends on the mode(s) that is/are selected. Generally the current lines (~~cf.~~see Figs 1A-1F) should not be interrupted. Normally it functions with a circular slot for all modes. It may also be ellipsoidal. For a rectangular resonator it may be rectangular.

The first and second resonators may also have other shapes, and that the shapes of the first and second resonators may be the same or different. The ground plane may also have the same size (and shape) as the first resonator or any other shape as long as it is not smaller than the first resonator.

Please amend the paragraph beginning at page 16, line 1, as follows:

In the figure input coupling means 4 in the form of an antenna are shown for input of microwave signals to the microwave device for exciting the relevant mode or modes. In principle any input/output coupling means can be used and the antenna is merely indicated for indication of an example on input coupling means. Different types of input/output coupling means are discussed in the Swedish patent application "Arrangement and Method Relating to Microwave Devices" filed on April 18, 1997 with the application No. 9701450-0 and US Patent 6,185,441 and the content of which herewith ~~is~~ are incorporated herein by reference. In this document it is among other illustrated how the coupling means can be used for application of a biasing voltage. It also illustrates examples on coupling means that can be used while still requiring separate

biasing means, as well as a number of state of the art devices. The present invention is not limited to any particular way of coupling microwave energy into/out of the device, the main thing being that the biasing voltage is applied to the second resonator, which is tunable, and which is coupled to another resonator which is not tunable, which resonators are coupled to one another such that redistribution of electromagnetic energy is enabled.

Please amend the paragraph beginning at page 16, line 24, as follows:

One example of a second resonator that can be used in a resonator apparatus according to the present invention was disclosed in Fig. 3. The second resonator 2 may also be a thin ~~parallell~~ parallel plate microwave resonator~~, t hin here meaning~~. The term "thin" means that it is thin in comparison with the wavelength in the resonator, λ_g, more specifically $d<\lambda_g/2$, wherein d is the thickness of the resonator 2, and λ_g is the wavelength in the resonator. (Generally the apparatus could be a thin film device, although bulk substrate devices are preferred, as discussed earlier.)

Please amend the paragraph beginning at page 17, line 1, as follows:

In Fig. 5 the equivalent circuit of the two coupled resonators 1,2 of Fig. 4 is illustrated. Z_{in} represents the input impedance of the arrangement R_1, C_1 represent the ~~resistor~~ resistance and the capacitor of the first, non-tunable resonator 1. R_2, C_2 represent the tunable components of the second resonator 2, and C_0 5 is the coupling capacitor coupling the first and second resonators to each other.

Please amend the paragraph beginning at page 18, line 11, as follows:

Figs. 7A illustrate the real and imaginary parts of the input impedance at zero applied voltage. Correspondingly Figs. 7B, 7C illustrates the real and imaginary parts of the impedance at a biasing voltage of 100V and 200V respectively. As can be seen from ~~the figures~~Figs. 7A – 7C, for zero biasing voltage (Fig. 7A) the resonant frequency will be about 2459.4 MHz, for a biasing voltage of 100V (Fig. 7B)it will be 2509.3 MHz and for an applied biasing voltage of 200V(Fig. 7C) it will be about 2530.9 MHz. The

frequency shift ΔF will be 49.9 MHz for 100V and 71.5 MHz for 200 V biasing voltage. In the given range of the applied voltage, the loss factor of the ferroelectric, tunable substrate material will change about 30 times. However, the total quality factor change will be no more than about ±30%. If the frequency band of the resonator is about 0.5 MHz, the resonator figure of merit will be $\Delta F/\Delta f \approx 71.5/0.5 \approx 140$. It should however be clear that Figs. 6A,6B,7A,7B,7C merely are included for illustrative and exemplifying purposes.

Please amend the paragraphs beginning at page 18, line 29 through page 19, line 24, as follows:

Fig. 8A shows one particular example of a first resonator 1A e.g. as in Fig. 4, which comprises a circular disk resonator. It comprises a non-tunable, high quality linear substrate 11A, a first conducting electrode 12A, which for example may be superconducting or even high temperature superconducting, and a second electrode 13A which for example is a larger than the substrate 11A and the first electrode 12A. It may for example also have the same size as the first electrode 12A. This second electrode plate 13A acts as a common ground plane for the first resonator 1A and for the second resonator 2A of Fig. 8B. The common ground plane 13<u>A</u> comprises coupling means 5A for coupling the first resonator 1A and the second resonator 2A to each other.

The second resonator 2A comprises a first electrode 22A disposed on a ferroelectric substrate e.g. of STO which is non-linear and has an (extremely) high dielectric constant. Biasing means comprising a variable voltage source V_{eB} 3 with connection leads is connected to the common ground plane 13A and to the first electrode plate 22A of the second resonator 2A. Preferably the TM_{020} modes are excited via input coupling means (not shown in this figure). The coupling means 5A may comprise a slot which is circular or ellipsoidal, and through which electromagnetic energy from the

second resonator 2A can be redistributed to the first resonator 1A upon application of a biasing voltage to the second resonator 2A.

Please amend the paragraph beginning at page 20, line 11, as follows:

In a corresponding manner <u>(see Fig. 9B)</u> the second resonator 2B comprises a first electrode plate 22B with a (high temperature) superconducting layer $22B_1$ covered by a non-superconducting metal layer $22B_2$. The first and second resonator 1B, 2B, like in the preceding embodiment, comprise a common ground plane, for both forming a second electrode 13B which, in this particular implementation, comprises a (high temperature) superconducting layer $13B_1$ covered on either side by a very thin non-superconducting metal film $13B_2$, $13B_3$. Alternatively the ground plane just consists of a superconducting layer. A biasing voltage is applied between the first and second electrodes 22B, 13B of the second resonator 2B and electromagnetic energy can be redistributed via coupling means 5B, which here comprises a rectangular slot, to the first resonator 1B. It should be clear that the coupling means does not have to be a rectangular slot, but it can be any kind of aperture giving the desired properties as far as transfer of electromagnetic energy is concerned for the concerned modes. It may e.g. be circular or ellipsoidal as well. Still further the electrodes may consist of normal metal only.

Please amend the paragraph beginning at page 20, line 31, as follows:

The inventive concept is also applicable to dual mode operating resonators, oscillators, filters whereby dual mode operation can be provided for in different manners, e.g. as disclosed in the patent application "Tunable Microwave Devices" <u>and US Patent</u> <u>US Patent 6,463,308</u> which was incorporated herein by reference.

Please amend the paragraph beginning at page 21, line 31, through page 22, line 18, as follows:

Fig. 12 illustrates the equivalent circuit of a two-pole filter 100 as in Fig. 11 which is connected by a transmission line section. In the figure it is illustrated the first resonator apparatus 10D with resistance R_{1D} and capacitance C_{1D} corresponding to the first non-tunable resonator 1D and the tunable resonator 2D comprising a ~~resistor~~ resistance R_{2D} and ~~capacitor~~ capacitance C_{2D} which resonators are coupled to each other by the coupling means 5D represented by a capacitor C_{04}. The inductances L_{04}, L_{004}; L_{05}, L_{005} of the resonators are also illustrated in the figure as explained earlier with reference to Fig. 6A, 6B, 7A, 7B. To the first resonator apparatus is connected a second resonator apparatus 10E comprising a first resonator 1E and second resonator 2E with the respective non-tunable and tunable components resistance R_{1E}, C_{1E} and R_{2E}, C_{2E} respectively and connecting capacitor C_{05} corresponding to coupling means 5E. It is supposed that the two-pole filter is connected by a transmission line section. In the exemplifying figure the characteristic impedance of the external line $Z_0 = 50$ Ohm, the characteristic impedance of the coupling line $Z_{01} = 45$ Ohm, and the electrical length of the coupling line at the central frequency is 80°.

Please amend the paragraph beginning at page 22, line 20, through page 23, line 2, as follows:

Figs. 13A, 13B are diagrams showing simulated lines of the tunable two-pole filter of Fig. 10. The insertion losses in dB and the return losses in dB correspond to the transmissions T and the reflectivity. Γ is given for three different values of a biasing voltage V. In Fig. 13A T1 corresponds to the transmission as a function of the frequency at zero biasing voltage, T_2 corresponds to the transmission as a function of the frequency in GHz for a biasing voltage of 100V and T_3 is the transmission for a biasing voltage of 200V. Correspondingly the reflectivities Γ_1, Γ_2, Γ_3 are indicated in Fig. 13B for biasing voltages 0V, 100V, 200V, respectively. As can be seen the insertion losses and the return losses are maintained even at a higher biasing voltage. The average bandwidth is 15

MHz, and the range of tunability is approximately 70 MHz with an insertion loss ≈ 0.5 dB. The drastically increasing loss factor of the ferroelectric material of the second resonator is largely compensated for through the application of the inventive concept.